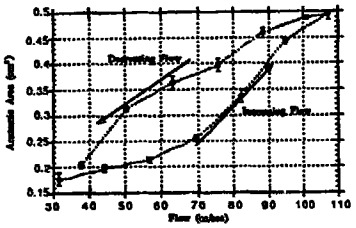
aortic valve bioprosthesis obtained after chronic implantation in a sheep for 18 months. Flows through the valve were varied from 30 cc/sec to 108 cc/sec. A high resolution digital video camera imaged the open leaflets for measurement of actual anatomic valve opening areas (AOA). AOA exhibited hysteresis behavior as flow rate changed (Figure). For flows increasing from 30 to 70 cc/sec, AOA increased gradually. Increasing flows past 70 cc/sec caused an abrupt rise in AOA. As flow rate decreased from 108 cc/sec, AOA changed along a completely different path, resulting in different AOA's for equal flow rates depending on whether flow rate was increasing or decreasing.



This hysteresis behavior is presumably due to the non-linear elastic characteristics of the rigid valve leaflets which require a critical pressure gradient to be exceeded before further opening occurs. Such behavior may have significant impact on clinically used techniques such as the Doppler continuity equation for measurements of effective orifice areas.

963-11 Can the Closure Impact of Mechanical Heart Valves (MHV) Release Microbubbles in Gas-Saturated Solutions? An *In-Vitro* Study

Edmond Rambod, Mory Gharib, Denis J. Levy, Simcha Milo [1], Shimon Reisner [1], David J. Sahn [2]. *California Institute of Technology, Pasadena, CA;* [1] *Rambam Medical Center and the Technion-School of Medicine, Haifa, Israel;* [2] *Oregon Health Sciences Univ., Portland, OR*

Purpose: Recent clinical reports have indicated echocardiographic observations of bright mobile echoes, often called Spontaneous Echocardiographic Contrast (SpE), in the LV and LA during post-operative studies in patients with MHV. According to their nature and signal intensities of Doppler spectrum, some of these echoes have been categorized as *gaseous emboli.* Our primary goal was to utilize the most recent innovations in pulsed flow simulator design combined with advanced laser video flow imaging and ultrasound technologies to fundamentally investigate and understand the mechanism responsible for the release of blood's gas content and the formation of microbubbles associated with MHV closure.

Methods: Our heart pulsed flow simulator with a flexible and transparent left ventricle model generated physiological flow and pressure conditions, $(LAP)_{peak}$ = 8 mmHg, $(LVP)_{peak}$ = 130 mmHg, $(dP/dt)_{LV}$ = 1800 mmHg/s, $(SP)_{mean}$ = 100 mmHg, HR = 60 bpm, SR = 35%, CO = 5 l/min. A 31 mm bileaflet mechanical and a 23 mm bioprosthesis were selected as mitral and aortic valve substitutes, respectively. A *Vingmed CFM750* ultrasound machine was used to perform M-mode Doppler and 2D-echo of long and short axis planes. An Argon-Ion laser beam and a high-resolution CCD camera were used for high-speed laser video flow imaging.

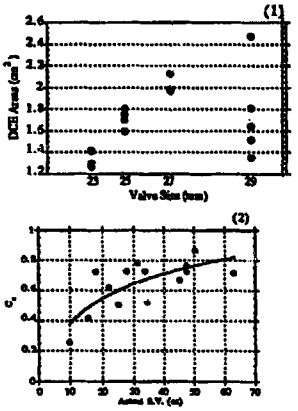
Results: High-speed videography of the mitral valve depicted bright bubbles formed in the immediate vicinity of the mitral valve upon valve closure, traveling in the LA before passing through the valve during the diastole. Spectral Doppler ultrasound images best detected these bubbles, their nature, and their intensities.

Conclusions: Our *in-vitro* observations confirmed that the dissolved gas in a saturated solution can be extracted at valve closure. Such a closure process creates a strong deceleration of the leaflet and a sudden pressure drop which generates vortical structures on the atrial side of the valve in the form of *stopping vortex.* The large gas concentration gradient then promotes the rapid process of *rectified diffusion* of the dissolved gas from the narrowing gap to the low pressure vortex core which ultimately, results in formation of gas bubbles on the atrial side. Further studies are needed to determine the exact chemical content of these bubbles as well as their clinical significance.
Supported by NIH grant # PHS 1 7R01 HL 43287-03.

963-12 Flow Dependence of the Doppler Continuity Equation for Bileaflet Mechanical Valves: Studies in an Animal Model

Robin Shandas, Michael Jones, David Solowiejcyk, Robert Manduley, Izumi Yamada, Lilliam Valdes-Cruz. *The Children's Hospital, Denver, CO; LAMS-NHLBI, Bethesda, MD*

Questions regarding the dependence of the Doppler continuity equation (DCE) on flow volume and valve size for mechanical valves remain unanswered. *Methods:* We calculated effective orifice areas (EOA) using the standard DCE with known electromagnetic flow meter measured stroke volumes (9–63 cc/beat) on 8 sheep with bileaflet mechanical valves of various sizes (23–29 mm) chronically implanted in the mitral position. Anatomic planimetered areas (APA) of each valve varied from 2.07 cm^2 (23 mm valve) to 4.1 cm^2 (29 mm valve). *Results:* For 23–27 mm valve sizes, EOA varied little with flow. However, EOA changed from 1.36 cm^2 to 2.48 cm^2 with flow for the 29 mm valve (Figure 1). The contraction coefficient (Cc) defined as EOA/APA was found to vary in logarithmic fashion with flow (Figure 2) for all valves, indicating a strong flow dependence at low flows and implying a pressure gradient effect on EOA calculations using DCE.



Conclusions: The DCE applied to calculate forward EOA for bileaflet mechanical valves in the mitral position shows dependence on flow and pressure gradient, an effect that becomes predominant in larger valves and lower flow states.

963-13 Streptokinase Tretament for Late Thrombosis of the Bjork-Shiley Tricuspid Prosthesis; 12 Years Experience

Dejan Boskovic, Bosiljka Vujisic, Milan Petrovic, Predrag Mitrovic, Darinka Boskovic, Ivo Elezovic. *Cardiology Clinic, Clinical Centre, Belgrade, Yugoslavia*

From January 1973 to August 1995 eleven patients (pts) with 20 episodes of thrombosis of tricuspid Björk-Shiley prosthesis were initially treated with fibrinolysis – Streptokinase (S). Thrombosis occurred late in all 11 pts (mean 70.1 months after the operation). Immediate results were excellent in all 11 pts. Complete regression of clinical, echocardiographic and cineradiographic signs of prosthetic thrombosis was seen in all 11 pts. Long term follow-up extends from 24–144 months. In four pts long term results are excellent. Prosthetic rethrombosis occurred in 7 pts, 4, 7, 8, 9, 14, 38, 40 months after initial treatment with S. Repeat treatment with S was carried out in 6 out of 7 pts and was successful in all 6 pts. In three pts second episode of prosthetic rethrombosis occurred 4, 24, 27 months after repeated administration of S. It was successfully treated with third administration of S. Twelve years follow-up showed two late deaths (1 operation for prosthetic rethrombosis, 1 sudden death). Conclusion: our results suggest that initial fibrinolytic therapy for thrombosis of tricuspid Björk-Shiley prosthesis is highly effective. Late recurrence occur in 63.6% of our pts. Repeated administration of S was successful in all pts with prosthetic rethrombosis.

963-14 Resistance Is Better Than the Continuity Equation for Assessing Replacement Valves In the Mitral Position

Richard A. Cooke, Zhibin Wang, John B. Chambers. *Adult Echocardiography, Guy's Hospital, Guy's and St Thomas' NHS Trust, London, U.K.*

There is no reliable method of quantifying forward flow through replacement valves in the mitral position. Resistance (mean ΔP/flow) and effective area by the continuity equation have not yet been validated. We therefore compared these measures against an independent standard provided by directly observed orifice area (OA) in five biological valves with orifice areas ranging from 0.2 cm^2 to 2.3 cm^2. We used a pulse simulator and quasiphysiological flow curves with upto 20 different stroke volume/rate combinations giving transmitral flow rates of 3.1 l/min to 16.9 l/min. Observed orifice area was measured using high speed video, pressure drop with strain gauge transducers and Doppler waveforms using a Vingmed SD50 system with a 1.9